US Army Corps of Engineers
Detroit District

FEASIBILITY STUDY FOR THE BOARDMAN RIVER

GRAND TRAVERSE COUNTY, MICHIGAN

APPENDIX E – HABITAT ANALYSIS

GREAT LAKES FISHERIES AND ECOSYSTEM RESTORATION PROGRAM

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1 OVERVIEW

As part of the Boardman River Ecosystem Restoration Project, an effort was undertaken to measure and quantify the project's benefit to habitat. The benefits to habitat are quantified by analyzing the alternatives effect on fisheries, wetlands, and sea lamprey protection. With the quantified habitat effects, different project alternatives and their associated impacts to fish and wetland habitat can be compared, as well as, analyzed economically to ensure that improvements to these habitat are cost effective.

Quantifying effects to fish habitat was accomplished by the use of habitat suitability index (HSI) models developed by the U.S. Fish and Wildlife Service (USFWS). These HSI models were used to assess riverine habitat for specific fish species and used to calculate annual average habitat units (AAHU) that would be lost or gained for each project alternative. The quantity (river miles) and quality (suitability index) of coldwater habitat was assessed using this approach. The importance of the habitat type is represented through the selection of fish species analyzed. For example, because of the project's objective of restoring coldwater habitat, HSI's for coldwater fish species were selected. Thus, the importance of coldwater is deemed to be greater than other habitat types.

Wetlands were assessed for quality, quantity and importance. To assess the quality of wetlands the Michigan Rapid Assessment Method (MiRAM) was applied. This method provided a function (importance) and value score (quality) for the wetlands impacted by each project alternative. With the MiRAM score and wetland quantity, an AAHU score could be calculated to analyze the different project alternatives' impacts to wetland habitat.

Sea lamprey protection was also assessed for quantity, quality and importance. Quantity of sea lamprey protection was measured as river miles protected by a physical barrier to prevent infestation. Quality and quantity were assessed based on how protective the proposed barrier would be and since U.S. Fish and Wildlife requirements are stringent in this area, all lamprey protection measures were considered to be important and of high quality. This resulted in the river miles protected being the metric that drove the AAHU scores for this component of the assessment.

2 PROJECT DESCRIPTION

The Boardman River originates in Grand Traverse and Kalkaska Counties, MI and flows approximately 49 miles before entering West Grand Traverse Bay at Traverse City, MI. The proposed project consists of decommissioning and modification/removal of up to three dams along the Boardman River: the Union Street Dam at river mile 1.1; the Sabin Dam at river mile 5.3; and the Boardman Dam at river mile 6.1. Although all three dams are being considered for modification or removal, several alternatives would be evaluated including repairing the dams and/or leaving them in place. Project objectives include reconnecting and restoring tributary habitat, allowing unimpeded movement of woody debris and sediment materials through the river system, negating thermal disruption, and restoring the natural balance between coldwater species. These objectives must be accomplished without transporting pollutants into Grand Traverse Bay of Lake Michigan or allowing upstream migration of invasive aquatic species.

The well-documented effect of the dams over the last three decades is a reduction in populations of trout and other aquatic species immediately upstream and downstream of the dams. If the dams were allowed to remain in place they would continue to fragment the Boardman River into discontinuous segments, leading to continued loss of genetic diversity in the trout populations, blockage of migratory Great Lakes fish at the Union Street Dam, as well as continued habitat degradation, thermal disruptions, and induced species disruptions. Trout populations, biomass, and individual fish size would be expected to remain artificially low, coolwater fish populations would experience negative effects (including an inability to sustain their populations), and species such as the lake sturgeon would not have access to the river

3 HSI AND AAHU MODELING OVERVIEW

As part of the Boardman River Detailed Project Report (DPR) process, the use and suitability of impacted habitat was assessed for the Boardman River fisheries, wetlands, and sea lamprey protection. Fish habitat was assessed using existing HSI models developed by the USFWS and modifying them with regional field data. Both the current status of the Boardman River and the potential project alternatives were analyzed in terms of habitat suitability (quality and importance) for each of the selected fish species within 10 river segments (quantity). The HSI scores for each segment were multiplied by the river segment lengths (in miles) to account for distance and available habitat. This allowed the segment-specific HSI scores to take into account not only the quality and importance of habit, but also its quantity and availability. These segment-specific HSI scores are able to estimate how important and desired fish species and their associated habitat would be impacted by the different project alternatives.

The species-specific HSI scores for each river segment were then used to calculate AAHU scores for each of the project alternatives. To produce AAHU scores, HSI scores were subjected to several correction factors and mathematical equations. The results of these HSI and AAHU assessments can be considered when selecting project alternatives and used to improve the habitat of fisheries with the Boardman River.

Wetland habitat was quantified by scoring each wetland type using MiRAM to assess the functions and values of individual wetlands. The MiRAM scores for individual wetlands (quantity and importance) were then multiplied by the wetland size (quantity) to produce an AAHU score. This allowed the wetland-specific AAHU scores to take into account the quality, importance, and quantity of habitat. The AAHU scores are able to estimate how individual wetlands would be impacted by the different project alternatives. The results of these MiRAM and AAHU assessments can be considered when selecting project alternatives and used to improve the wetland habitat associated with the Boardman River.

The benefits related to controlling sea lamprey were quantified using miles of river protected by a physical barrier to prevent infestation. Protected river miles (quantity) were designated as AAHU values to measure how the opening of river segments for increased fish passage can also results in the colonization of the invasive sea lamprey and the degradation of aquatic habitat. It was assumed that all proposed barriers would be equally effective (quality) and that all river segments are of equal importance. Thus, the driving factor in the sea lamprey related AAHU score was river miles protected.

3.1 Intrinsic Conditions of HSI and AAHU

The AAHU calculated for this project relied on quantifying the quality and quantity of habitat. The importance of the existing or created habitat was assessed through the selection fish species. Due to the project objective of restoring coldwater characteristics to the river, coldwater species were selected for evaluation. The selection of coldwater species made coldwater habitat more important than other habitat types for this evaluation. Use of different species that relied on different habitat types would result in different habitat unit output.

In northern Lower Michigan coldwater streams are considered more valuable than warmwater lotic habitat because they are a limited resource in the lower peninsula of Michigan, making up only about 25 percent of stream segments. These streams naturally tend to have higher densities of game fish and provide spawning grounds and nursery areas for Great Lakes fish. The economic worth of coldwater streams has been estimated at over $11,000/mile/year based on angler-day values (O’Neal 2006). These factors support the importance of protecting/restoring coldwater streams in Michigan. The Boardman River is a designated Natural River under the State of Michigan Natural Rivers Program and, outside of the study area, it features 36 lineal miles of Blue Ribbon Trout Stream designated by the Michigan Department of Natural Resources (MDNR) Fisheries Division. The river is considered one of the top 10 best trout streams in Michigan and supports self-sustaining populations of brown, brook, and rainbow trout. Mitigating the ecosystem disruption to the study area by removing the Boardman River dams would add miles of top quality trout stream, restore connectivity and coldwater characteristics of the Boardman River, and potentially increase the diversity of species moving between the Great Lakes and the river.

3.2 Fisheries HSI and AAHU Modeling

The HSI models and associated suitability index (SI) curves were developed by the USFWS from reviewing literature concerning a species' habitat requirements and preferences then synthesizing the information into HSI models, which are scaled to produce an index between 0 (unsuitable habitat) and 1 (optimal habitat). The SI reflects the quality of habitat for each species. Assumptions used to transform habitat use information into these mathematical models were noted and any guidelines for model application were described. Any models found in the literature which could also be used to calculate an HSI are cited, and simplified HSI models, based on what the authors believe to be the most important habitat characteristics for a species, are presented. The USFWS HSI models and SI curves developed are species-habitat relationships that reflect the scientific community's understanding of what represents quality habitat for the selected species.

3.2.1 Selection of Species

Correspondence with the USFWS and the MDNR were used to assist in the selection of species for habitat analysis in the Boardman River system. The fish species selected were all native to the Great Lakes region, additionally; they currently exist within the Lake Michigan-Boardman River system and have been identified as coldwater species that should benefit from the proposed ecosystem restoration alternatives. Thus, their habitat would serve as an indicator of importance when evaluating, selecting, and designing the Boardman Dam ecosystem restoration alternatives. The following paragraphs summarize fish species that were selected for HSI modeling.

3.2.1.1 Resident Coldwater Species Selected

There are several fish species found within the coldwater stream sections of the Boardman River that make suitable candidates for HSI modeling including brook trout (*Salvelinus fontinalis*), longnose dace (*Rhinichthys cataractae*), blacknose dace (*Rhinichthys atratulus*), mottled sculpin (*Cottus bairdii*), and slimy sculpin (*Cottus cognatus*). These species all have resident populations in the coldwater sections of the Boardman River, spending their entire lifespan in the river habitat. They have similar habitat requirements including clear, coldwater, silt-free, rocky substrate, and an abundance of cover. Additionally, these fish are the species most likely to benefit from achieving the project's objectives. Increased coldwater stream habitat, which is a requirement of these species, would result in greater HSI and AAHU scores. Because the optimal habitat for these species mirrors the project objectives they make excellent species for HSI modeling.

The brook trout was selected for HSI modeling because it is one of the top predator species in the coldwater stretches of the Boardman River. Applying HSI modeling to this species provides an in-depth habitat analysis of how the project alternatives would impact an important coldwater species. The brook trout is a top predator species, desirable species for recreational fishing and it is the only native, stream-residing salmonid in Michigan. The existing populations of brook trout have been greatly impacted by the warming effects of the impoundments and would gain a great deal of usable habitat if coldwater habitat was restored. Consequently, HSI and AAHU scores for the brook trout increased with dam removal alternatives that restore coldwater stream habitat and lower water temperatures. An HSI model for brook trout has been developed by the USFWS (Raleigh 1982).

The longnose dace was also chosen for HSI modeling to provide habitat analysis for the coldwater forage fish niche. Although they do not provide any fishing opportunities, these small forage fish are an important part of the aquatic ecosystem and have a similar role as other forage species within the Boardman River including the blacknose dace and sculpin species. Since the sculpin and dace species use the same habitat and have the same prey items, the species-specific HSI models for sculpin and dace species would most likely produce similar results for these species. The longnose dace was selected since it already has a proven HSI model developed by the USFWS (Edwards et al. 1983). It prefers swift-flowing steep gradient streams and is currently only found in one river segment of the Boardman River between the former Brown Bridge Dam and Boardman Pond, while the blacknose dace is found in five river segments. The HSI model for longnose dace is also simpler and requires less measurable variables, which increases the usefulness of the model because of the limited availability of habitat data for the Boardman River system.

3.2.1.2 Migratory Fish Species Selected

The lake sturgeon (*Acipenser fulvescens*) and lake trout (*Salvelinus namaycush*) are likely the only native, migratory, Lake Michigan fish species that could be candidates for HSI modeling. The lake sturgeon is a State-threatened species that generally use large, hard-bottom rivers to spawn and have been observed migrating up the Boardman River to the Union Street Dam. Historically, lake sturgeons probably spawned in the Boardman River, but are now unable to pass through the fish ladder at the Union Street Dam. If sturgeons were able to pass through the Union Street Dam (which is not slated to be removed) via a new fish passage or trap-and-transfer facility and the upstream dams were removed, sturgeon would gain access to an enormous amount of new potential spawning habitat and HSI and AAHU scores would be high. A HSI model has not been developed for lake sturgeon; however, a model has been developed for another sturgeon species, the shortnose sturgeon (*Acipenser brevirostrum*) (Crance 1986). This model was used as a template and altered to produce a lake sturgeon HSI model based on field-collected data from current lake sturgeon studies in Michigan (Weiten 2011).

Performing HSI modeling on a Lake Michigan migratory fish was ideal, especially a species that is protected by the State of Michigan and the focus of several, recent restoration studies. Consequently, the lake sturgeon was selected for HSI modeling from migratory fish group. Lake sturgeons are likely to migrate upstream and use the Boardman River for spawning activities and a suitable HSI model template already exists for this species.

3.2.1.3 Warmwater-Coolwater Fish Species Not Selected

There are three fish species found within both the impoundments and the coldwater stream sections of the Boardman River that were potential candidates for HSI modeling, walleye (*Stizodstedion vitreum vitreum*), yellow perch (*Perca flavescens*), and white sucker (*Catostomus commersonii*). Walleye often migrate up rivers to spawn because of their preference for good water circulation, rocky substrate, and current. They have been recorded inhabiting Boardman Lake and observed upstream in the Boardman River, presumably to spawn. The impoundments at the Sabin and Boardman Dams do not support walleye populations so the dam removal alternatives would provide walleye with more spawning habitat. Yellow perch have been observed in every segment of the Boardman River System, except for the South Branch. Although the impoundment habitat provides better habitat than coldwater stream sections, adult perch need to be exposed to an extended period of coldwater temperatures to ensure ripening of eggs. White sucker were recorded in every stretch of the Boardman River sampled and can tolerate a broad range of environmental conditions. HSI models have previously been developed for all these species and walleye and yellow perch are both important gamefish.

This group of fish was not selected for HSI modeling. They are warmwater-coolwater species which are not the targeted species for this restoration project and thus, they are less important in the context of meeting project objectives. For example, the net benefit from restoring coldwater habitat (a project objective) would be minimal for all three species. HSI and AAHU scores would not show a definitive increase in habitat suitability if project objectives were met; thus they were not selected for evaluation. For example, yellow perch and white sucker can live in a variety of habitats, including warmwater lakes and are more tolerant of varying conditions.

3.2.2 Methodology

In order to apply these species-specific HSI models and SI curves to the Boardman River project, URS developed a scoring matrix to rate the Boardman River for each of the three selected fish species. For each species, a spreadsheet was created that calculated SI values for each of the model variables. These SI values are used to calculate an overall HSI score for that segment of the Boardman River. Ten distinct segments of the Boardman River were identified in preliminary field studies and feasibility reports performed by Environmental Consulting and Technology, Inc. (ECT 2009). They are described in Table 1 and Figure 1 below. These 10 segments were all scored individually and multiplied by their lengths in miles to produce an HSI score for each Boardman River segment for its current state and the project alternatives.

Table 1: River Segments	
Segment	**Description**
1	From Union Street Dam downstream to Lake Michigan, and Hospital (Kids) Creek
2	Union Street Dam impoundment, also known as Boardman Lake
3	From Sabin Dam downstream to Union Street Dam impoundment, or Boardman Lake
4	Sabin Dam impoundment, also known as Sabin Pond, upstream to Boardman Dam
5	Boardman Dam impoundment, also known as Boardman Pond or Keystone Pond
6	From the former Brown Bridge Dam downstream to Boardman Dam impoundment
7	Former Brown Bridge Dam impoundment area, also known as Brown Bridge Pond
8	From the confluence of the North and South Branches of the Boardman River, also known as the Forks, downstream to the former Brown Bridge Dam impoundment area
9A	North Branch of the Boardman River
9B	South Branch of the Boardman River

For the HSI modeling, the Brown Bridge Dam was considered to have been removed. A separate project, funded by a different entity, recently removed this dam.

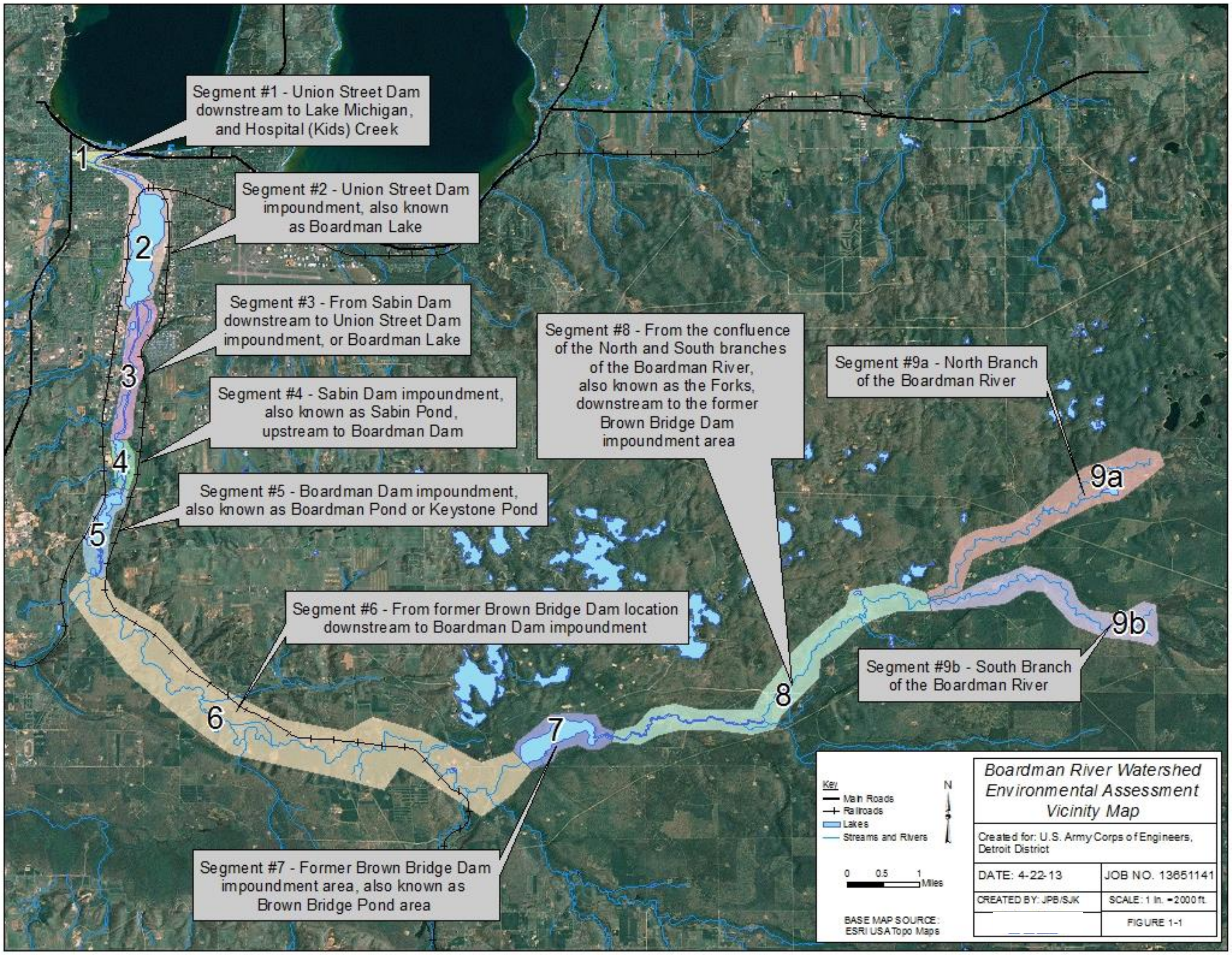

Figure 1: Boardman River Feasibility Study – Study Area

3.2.2.1 HSI Model Alterations

The scoring spreadsheets for the brook trout and longnose dace were based entirely off the USFWS HSI models and used the same variables and SI curves. The lake sturgeon model was based of the USFWS HSI model for the shortnose sturgeon but altered to include regional field data. The shortnose sturgeon model served as an excellent template since it incorporated both spring spawning and summer foraging behavior in only freshwater riverine and reservoir habitat. To produce the HSI model for lake sturgeon, all the variables remained the same, however, their SI curves were altered to represent lake sturgeon behavior. Specifically, V2 (Mean Water Velocity During Summer), V3 (Predominate Substrate During Summer Foraging), V4 (Mean Water Temperature During Spring Spawning), and V6 (Predominate Substrate During Spring Spawning) were slightly altered to better represent lake sturgeon activities based on current literature and field data (Weiten 2011). Information was provided by Grand Valley State University's Annis Water Research Institute who are currently performing lake sturgeon spawning and habitat use research on the Muskegon River, Kalamazoo River, and Grand River in conjunction with the MDNR (Weiten 2011). Table 2 below details the alterations made to the shortnose sturgeon HSI model, specifically the SI curves, to make it applicable to lake sturgeon.

Table 2: Lake Sturgeon HSI Model Alterations

Variable	Variable Description	Alteration
2	Mean Water Velocity During Summer	Changed the 0 centimeters per second velocity HSI score from 0.8 to 1.0.
3	Predominate Substrate During Summer Foraging	Changed the macrophyte substrate HSI score from 1.0 to 0.0.
4	Mean Water Temperature During Spring Spawning	Altered spawning temperature range to between 8.8 degrees Celsius (°C) and 21.1°C with the optimal temperatures between 11.5°C and 16.0°C. The previous temperature range was between 7.2°C and 18.0°C with the optimal temperatures between 10.0°C and 16.0°C.
6	Predominate Substrate During Spring Spawning	Changed the macrophyte substrate HSI score from 0.2 to 0.0.

3.2.2.2 Data Sources

The Boardman River data were collected from a variety of sources to populate the HSI spreadsheets and calculate HSI scores. Sources included preliminary field reports from ECT, MDNR fisheries and water quality surveys, U.S. Geological Survey gauges, dam breach/drawdown study by Prein & Newhof, and Federal Energy Regulatory

Commission environmental inspection reports. Table 3 details the primary sources of data for completion of the HSI models.

Table 3: Reference Documents		
Title	**Author**	**Date**
Boardman River Feasibility Study–A Report on the Boardman River Fisheries Habitat Survey & Data Collection	Environmental Consulting and Technology, Inc. (ECT)	January 2009
Boardman River Feasibility Study–A Report on the Boardman River Fisheries Habitat Survey & Data Collection	ECT	January 2009
Section 506 Great Lakes Fishery and Ecosystem Restoration Preliminary Restoration Plan for the Boardman River Mainstem Grand Traverse County, Michigan	U.S. Army Corps of Engineers (USACE)	February 2006
Michigan Surface Water Information Management System	Michigan Department of Natural Resources	1967–2005
National Water Information System	U.S. Geological Survey	1953–2010
Boardman River Feasibility Study–Boardman Dams Breach/Drawdown Study	Prein & Newhof	January 2009
Environmental Inspection Report for Sabin Dam	Federal Energy Regulatory Commission	May 2, 2002
Boardman River Feasibility Study–A Report on Boardman River Existing Sediment Chemistry Data	ECT	April 2008
Project Information Sheet	USACE	February 2011

Information concerning the lake sturgeon (*Acipenser fulvescens*) population within the Boardman River and its habitat suitability for sturgeon spawning and foraging activities was taken primarily from the following sources:

- MDNR. 1997. *Lake Sturgeon Rehabilitation Strategy*. Fisheries Division Special Report 18. Editors: Elizabeth M. Hay-Chmielewski and Gary E. Whelan, August 25, 1997.
- MDNR. 2011. *Draft Lake Sturgeon Rehabilitation Strategy*. Fisheries Division. Editors: Dr. Daniel B. Hayes and Dr. David C. Caroffino.

- USFWS. 2008. *Lake Sturgeon Population Status in Great Lakes Basins Tables and Figures*.
- Kalish, Todd. 2011. Personal Communications. *Appendix 3: Distribution Maps of Fish Species within the Boardman River Watershed.* MDNR.

The MDNR's *Lake Sturgeon Rehabilitation Strategy* published in 1997 stated that the Boardman River was included in the historic distribution of lake sturgeon in Michigan's inland waters based on recorded catches or biological samples. It also considered the Boardman River as a candidate river for lake sturgeon rehabilitation or enhancement. According to this report, the Boardman River has a documented sturgeon population and has a medium rating for sturgeon suitability. The Table 4 below details how the Boardman River was rated as a candidate river.

Table 4: Boardman River Ratings for Lake Sturgeon Rehabilitation

Population Status	Discharge	Gradient	Barrier	Deep Habitat	Spawning Habitat	Temperature	Suitability
Yes	Medium	Potentially High	High	Low	Yes	Coolwater, Coldwater	Medium

The MDNR's *Lake Sturgeon Rehabilitation Strategy* drafted in 2011 does not include the Boardman River. It does not have the Boardman River listed as containing a known lake sturgeon population. However, it does state that because of low sturgeon numbers and inherent sampling difficulty, abundance and trajectory data are lacking for some lake sturgeon populations. When making management decisions in such cases, the MDNR Fisheries Division used best professional judgment and the precautionary principle, ensuring that conservative and protective actions are taken if uncertainty about a population exists.

The USFWS document contains tables and figures detailing the distinct populations of lake sturgeon throughout the Great Lakes. It lists the Boardman River as having an extirpated lake sturgeon population, however, adults are occasionally observed.

The fish distribution maps for the Boardman River, supplied by Todd Kalish of the MDNR, are generated from fish sampling data. It has lake sturgeon occurring within the Boardman River from Grand Traverse Bay up to the Union Street Dam, as well as, Kids Creek.

3.2.3 Results

The dams and impoundments on the Boardman River impair coldwater fish habitat by physically blocking the river and creating large areas of warmwater habitat. By segmenting the river systems, dams can prevent recolonization and movement of fish species into areas that may have undergone die-offs or population fluctuations due to water temperature changes, water regime alterations, introduced species, and increased predation/recreational fishing. Additionally, habitat connectivity increases genetic diversity of a species by increasing the gene pool and suppressing inbreeding. URS incorporated habitat connectivity into account during HSI modeling, where applicable, based on current fish distribution maps provided by the MDNR. The fish distribution maps were used to identify river segments where fish species have been excluded. The assessment of alternatives took this into account by assuming that fish passage or dam removal would allow species to recolonize river segments.

3.2.3.1 HSI Model Results

Segment-specific HSI scores for each project alternative take into account the quality, quantity, and importance of habitat associated with the Boardman River. These scores show how removing or modifying a dam affects habitat quality and availability, since some project alternatives impact river connectivity and can potentially "open up" several river segments for an individual fish species based on its presence and/or absence. This was especially crucial for the lake sturgeon, which is excluded from the majority of the Boardman River as a result of the Union Street Dam. For each fish species, all the potential alternatives were modeled, and Tables 5 through 7 list the HSI scores for each species and alternative. HSI scores for each alternative take into account the recent removal of the Brown Bridge Dam.

Table 5: Brook Trout Habitat Quantity and Quality (HSI) Scores

Alternative	Segment									
	1	2	3	4	5	6	7	8	9A	9B
Length (miles)	**1.14**	**2.14**	**2.15**	**1.04**	**1.34**	**12.03**	**1.63**	**6.95**	**3.00**	**3.00**
1: No Action	0.00	0.20	0.00	0.20	0.00	0.39	0.47	0.48	0.40	0.40
2: Modify Union	0.00	0.20	0.00	0.20	0.00	0.39	0.47	0.48	0.40	0.40
3: Modify Union, Remove Sabin	0.00	0.20	0.00	0.94	0.00	0.39	0.47	0.48	0.40	0.40
4: Modify Union, Remove Boardman	0.00	0.20	0.00	0.20	0.94	0.39	0.47	0.48	0.40	0.40
5: Modify Union, Remove Sabin and Boardman	0.00	0.20	0.00	0.94	0.94	0.39	0.47	0.48	0.40	0.40
6: Remove Sabin	0.00	0.20	0.00	0.94	0.00	0.39	0.47	0.48	0.40	0.40
7: Remove Boardman	0.00	0.20	0.00	0.20	0.94	0.39	0.47	0.48	0.40	0.40
8: Remove Sabin and Boardman	0.00	0.20	0.00	0.94	0.94	0.39	0.47	0.48	0.40	0.40

* HSI scores for each river segment take into account the recent removal of the Brown Bridge Dam.

Table 6: Longnose Dace Quantity and Quality (HSI) Scores										
Alternative	**Segment**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9A**	**9B**
Length (miles)	**1.14**	**2.14**	**2.15**	**1.04**	**1.34**	**12.03**	**1.63**	**6.95**	**3.00**	**3.00**
1: No Action	0.00	0.00	0.00	0.00	0.00	0.56	0.62	0.68	0.68	0.68
2: Modify Union	0.00	0.00	0.00	0.00	0.00	0.56	0.62	0.68	0.68	0.68
3: Modify Union, Remove Sabin	0.00	0.00	0.00	1.00	0.00	0.56	0.62	0.68	0.68	0.68
4: Modify Union, Remove Boardman	0.00	0.00	0.00	0.00	1.00	0.56	0.62	0.68	0.68	0.68
5: Modify Union, Remove Sabin and Boardman	0.00	0.00	0.00	1.00	1.00	0.56	0.62	0.68	0.68	0.68
6: Remove Sabin	0.00	0.00	0.00	1.00	0.00	0.56	0.62	0.68	0.68	0.68
7: Remove Boardman	0.00	0.00	0.00	0.00	1.00	0.56	0.62	0.68	0.68	0.68
8: Remove Sabin and Boardman	0.00	0.00	0.00	1.00	1.00	0.56	0.62	0.68	0.68	0.68

* HSI scores for each river segment take into account the recent removal of the Brown Bridge Dam.

Table 7: Lake Sturgeon Quantity and Quality (HSI) Scores										
Alternative	**Segment**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9A**	**9B**
Length (miles)	**1.14**	**2.14**	**2.15**	**1.04**	**1.34**	**12.03**	**1.63**	**6.95**	**3.00**	**3.00**
1: No Action	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2: Modify Union	0.61	0.50	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3: Modify Union, Remove Sabin	0.61	0.50	0.71	0.84	0.00	0.00	0.00	0.00	0.00	0.00
4: Modify Union, Remove Boardman	0.61	0.50	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5: Modify Union, Remove Sabin and Boardman	0.61	0.50	0.71	0.97	0.70	0.70	0.70	0.70	0.70	0.70
6: Remove Sabin	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7: Remove Boardman	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8: Remove Sabin and Boardman	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* HSI scores for each river segment take into account the recent removal of the Brown Bridge Dam.

3.2.3.2 AAHU Results

The species-specific HSI scores for each river segment were used to calculate AAHU scores for each of the project alternatives by:

- Correcting for fish passage in segments associated with dam modification to account for the success rates of sturgeon passage (Union Street Dam = 25 percent, Sabin Dam = 12.5 percent, and Boardman Dam = 6.25 percent);
- Correcting by a factor of 100 to remove decimals;
- Summing HSI scores for the three fish species to produce a total HSI score for each river segment; and
- Summing river segment HSI scores to produce an AAHU score for each project alternative.

AAHU scores for each alternative are found in Tables 8 and 9. Estimated success rates of fish passage were used to generate correction factors for the Union Street Dam, the Sabin Dam, and the Boardman Dam for alternatives with fish passage mechanisms. The fish passage success rates for lake sturgeon entering the Boardman River were chosen based on the planned upstream and downstream passage mechanism and amount of water flow flowing through the mechanisms. The selected correction factors are intentionally conservative because of the uncertainty of lake sturgeon successfully inhabiting the Boardman River. Although there is quality foraging and spawning habitat for lake sturgeon within the Boardman River, whether sturgeon would be able to fully utilize it is unknown because of a number of factors including:

- The small population size of lake sturgeon using the lower reaches of the Boardman River;
- Variable success rates of passage mechanisms for sturgeon;
- Difficulty of lake sturgeon locating potential mates because of the small population size;
- Difficulty locating spawning sites due to unfamiliarity with the upper reaches of the Boardman River; and
- Potential increase in predation of juvenile sturgeon in natural channels designed for downstream passage.

Additionally, the conservative correction places more emphasis on the AAHU scores of the brook trout and longnose dace and lessens the impact of sturgeon AAHU scores. Brook trout and longnose dace currently inhabit the Boardman River and the estimated habitat benefits for each of the project alternatives are more reliable based habitat accessibility and current use of the Boardman River habitat. The worksheets and data used to calculate fisheries HSI and AAHU scores can be found in Attachment 1.

Table 8: Fisheries AAHU Scores for Project Alternatives											
Alternative	**Segment**										**Total**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9A**	**9B**	
Length (miles)	**1.14**	**2.14**	**2.15**	**1.04**	**1.34**	**12.03**	**1.63**	**6.95**	**3.00**	**3.00**	
2: Modify Union	70	70	38	21	0	1143	178	806	324	324	2973
6: Remove Sabin	70	43	0	202	0	1143	178	806	324	324	3089
3: Modify Union, Remove Sabin	70	70	38	224	0	1143	178	806	324	324	3176
9: Modify Sabin	70	43	0	21	0	1143	178	806	324	324	2908
10: Modify Union and Sabin	70	70	38	32	0	1143	178	806	324	324	2984
7: Remove Boardman	70	43	0	21	260	1143	178	806	324	324	3168
4: Modify Union, Remove Boardman	70	70	38	21	260	1143	178	806	324	324	3233
11: Modify Boardman	70	43	0	21	0	1143	178	806	324	324	2908
12: Modify Union and Boardman	70	70	38	21	0	1143	178	806	324	324	2973
8: Remove Sabin and Boardman	70	43	0	202	260	1143	178	806	324	324	3349
5: Modify Union and Remove Sabin and Boardman	70	70	38	227	283	1353	206	928	377	377	3928
13: Modify Sabin and Boardman	70	43	0	21	0	1143	178	806	324	324	2908
14: Modify Union, Sabin and Boardman	70	70	38	33	6	1195	185	837	337	337	3108
1: No Action	70	43	0	21	0	1143	178	806	324	324	2908

Table 9: Fisheries AAHU Scores vs. No Action Alternative	
Alternative	**Score Differential**
5: Modify Union and Remove Sabin and Boardman	1020
8: Remove Sabin and Boardman	441
4: Modify Union, Remove Boardman	325
3: Modify Union, Remove Sabin	268
7: Remove Boardman	260
14: Modify Union, Sabin and Boardman	200
6: Remove Sabin	181
10: Modify Union and Sabin	76
12: Modify Union and Boardman	65
2: Modify Union	65
13: Modify Sabin and Boardman	0
9: Modify Sabin	0
11: Modify Boardman	0

3.2.4 Conclusions and Limitations

Only the dam removal alternatives would significantly increase the HSI and AAHU scores for brook trout and longnose dace as a result of an increase in available habitat. The conversion of impoundment to riverine habitat would benefit both these fish species by providing more usable habitat, lowering water temperatures, and increasing current. These variables seem to be the limiting factors for these coldwater fish species along with, to a lesser degree, substrate type and riffle habitat.

HSI scores for lake sturgeon predictably increase for each alternative that provides access to additional reaches of the Boardman River. Any viable alternative to increase sturgeon habitat must include passage through the Union Street Dam. Fish passage through just the Union Street Dam significantly increases HSI scores by giving the fish access to Boardman Lake and the mainstem of the river. Removal or modification of the Sabin Dam would provide another slight increase in HSI score. However, the largest increase comes with the removal or modification of both the Sabin and Boardman Dams, which would provide access to the entire Boardman River system. The alternative that incorporates both dam removals and the Union Street Dam modification would provide the greatest increase in available habitat within the Boardman River for lake sturgeon by providing the most access to riverine habitat that is predicted to be suitable for lake sturgeon spawning and embryo development.

The main limitation to HSI and AAHU modeling efforts was imposed by the project goal to explore the potential to restore fish habitat by restoring the connectivity and coldwater characteristics of the Boardman River and potentially increasing the diversity of species moving between the Great Lakes and the river. The goal of coldwater stream restoration determined the fish species selected for HSI analysis, which ultimately led to increased HSI and AAHU scores for those project alternatives that maximized this habitat type. Consequently, the existing warmwater lotic habitat had relatively low AAHU scores. The value of the existing impoundments and associated fish species are similar to natural lakes common to the area. In the context of the selected HSI models and resulting AAHU, the warmwater impoundment habitat was valued less than coldwater riverine habitat based on the species selected and the project objective of restoring coldwater habitat. Suitable habitat for warmwater and coolwater species within the Boardman River is intrinsically counterproductive to the project goal of restoring coldwater stream habitat. The loss of the existing warmwater lotic habitat is a side effect of improving coldwater riverine habitat.

3.3 WETLAND AAHU MODELING

Assessing the impacts to wetland habitat is a crucial component of evaluating the proposed alternatives for the Boardman River Project. Wetlands play an integral role in the health of a river system. Wetland benefits include:

- Flood and Stormwater Control
- Protection of Subsurface Water Resources
- Pollution Treatment
- Erosion Control
- Wildlife and Fish Spawning and Forging Habitat
- Lowered Water Temperature through Shading
- Scenic, Recreational, Educational, and Cultural Uses

The need for wetland habitat to be quantified was achieved by scoring wetlands using MiRAM to assess their functions and values (i.e., importance and quality). Data for the MiRAM evaluation was taken from ECT's Wetland Determination Report and Detailed Analysis of the Effects on Wetlands, which were part of the Boardman River Feasibility Study. Field data and observations were also recorded from site visits performed by URS in May 2012.

The MiRAM scores (quality and importance) for individual wetlands were then multiplied by the wetland quantity (in acres) to produce an AAHU score. This allowed the wetland-specific AAHU scores to take into account the quality, quantity, and importance of wetland habitat. The AAHU scores are able to estimate how individual wetlands would be impacted by the different project alternatives. These individual wetland scores were then summed to create an overall AAHU score for each project alternative for comparison purposes.

Fieldwork that provided the data for modeling was collected after the 2007 drawdown of Boardman Pond. Habitat modeling was, therefore, able to take into account changes to the Boardman Pond wetlands after the 2007 drawdown that created additional acres of potential wetland habitat. Consequently, the No Action Alternative for this project would not change the water level in Boardman Pond from its current elevation, 17 feet below the original impoundment level. As a result of this decrease, changes due to the 2007 drawdown would become permanent and the additional wetland habitat would remain.

3.3.1 Michigan Rapid Assessment Method Description

Developed by the MDNR, MiRAM is a rating system meant for comparing a wetland's functional value to other wetlands in Michigan, regardless of ecological type. For AAHU Modeling, MiRAM would be applied to wetlands associated with Sabin Pond and Boardman Pond under the conditions of each project alternative. Consequently, the AAHU lost or gained for each project alternative can be compared to analyze the potential impacts of the project alternatives on wetland habitat.

The MiRAM evaluation contains two rating systems, the Narrative Rating and the Quantitative Rating. The Narrative Rating identifies the wetland types with exceptional ecological value, which automatically rates the wetland as high functional value. If the wetland is not identified as having high functional value by the Narrative Rating, then the Quantitative Rating must be completed. For data collection purposes, those wetlands rated as high functional value in the Narrative Rating can also be scored using the Quantitative Rating, but these wetlands would be considered to have high functional value regardless of the results of the Quantitative Rating. This process provides a quality and importance score for wetlands.

For AAHU modeling, wetland habitat requires quantification so only the Quantitative Rating of the MiRAM was applied. The Quantitative Rating is a series of metrics designed to provide a numerical score that reflects the total functional value of a wetland, which includes a wetland's ecological condition (integrity) and its potential to provide ecological and societal services (functions and values). The following are metrics included in the Quantitative Rating:

- Wetland Size
- Wetland Scarcity
- Average Buffer Width around the Wetland
- Intensity of Surrounding Land Use
- Sources of Water
- Connectivity
- Duration of Inundation/Saturation
- Alterations to Natural Hydrologic Regime
- Substrate/Soil Disturbance
- Habitat Alteration
- Habitat Structure Development
- High Ecological Value
- Forested Wetland
- Urban/Suburban Wetland

- Low-Quality Wetland
- Wetland Vegetation Components
- Open Water Component
- Coverage of Highly Invasive Plant Species
- Horizontal (Plan View) Interspersion
- Habitat Features
- Scenic, Recreational, and Cultural Value

With these metrics, the MiRAM assessments would favor wetlands associated with river restoration because of their large size, high plant diversity, forested habitat, complex hydrology, lack of invasive species, multiple habitat features, and scarcity. When wetland size is taken into account to produce AAHU scores, project alternatives involving dam removal would score high as a result of the additional acres of wetland habitat that is anticipated to form from draining of the impoundments.

3.3.2 Michigan Rapid Assessment Method Results

Figures 2 and 3 depict the wetlands associated with Sabin and Boardman Ponds for the No Action Alternative, after the emergency drawdown in 2007. Figures 4 and 5 show the potential impacts to wetlands following the removal of the Sabin and Boardman Dams. Tables 10 and 11 show the wetland type and acreage (quantity) for Sabin and Boardman Ponds for the No Action Alternative compared to wetland habitat estimated to form after dam removal. Tables 12 and 13 depict the MiRAM scores (quality and importance) along with the acreage (quantity). The AAHU scores for the project alternatives generated by MiRAM analysis are found in Tables 14 and 15. The worksheets and data used to calculate wetland HSI and AAHU scores can be found in Attachment 1.

3.3.3 Conclusions

Using MiRAM, AAHU scores favored project alternatives that created/preserved wetland habitat that had the following qualities: a large size, high plant diversity, forested habitat, complex hydrology, lack of invasive species, multiple habitat features, and scarcity. The project alternatives that involve dam removal scored high as a result of the additional acres of wetland habitat that is anticipated to form from draining the impoundments. Project alternatives that scored poorly were those that only modified dams without removal. These alternatives scored similar to the No Action Alternative since the water levels of the impoundments remained that same and no new wetlands were created.

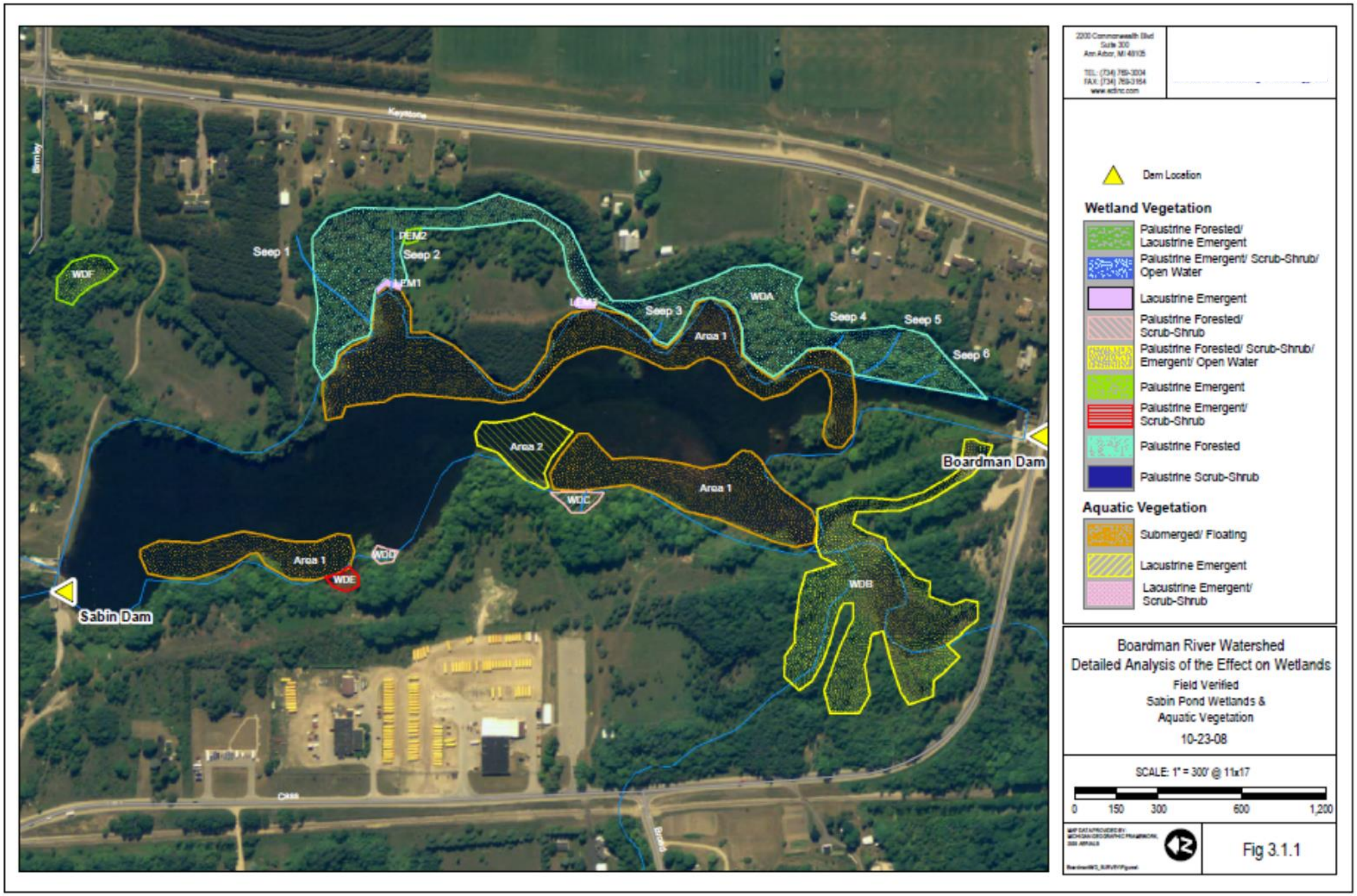

Figure 2: Sabin Pond Wetlands

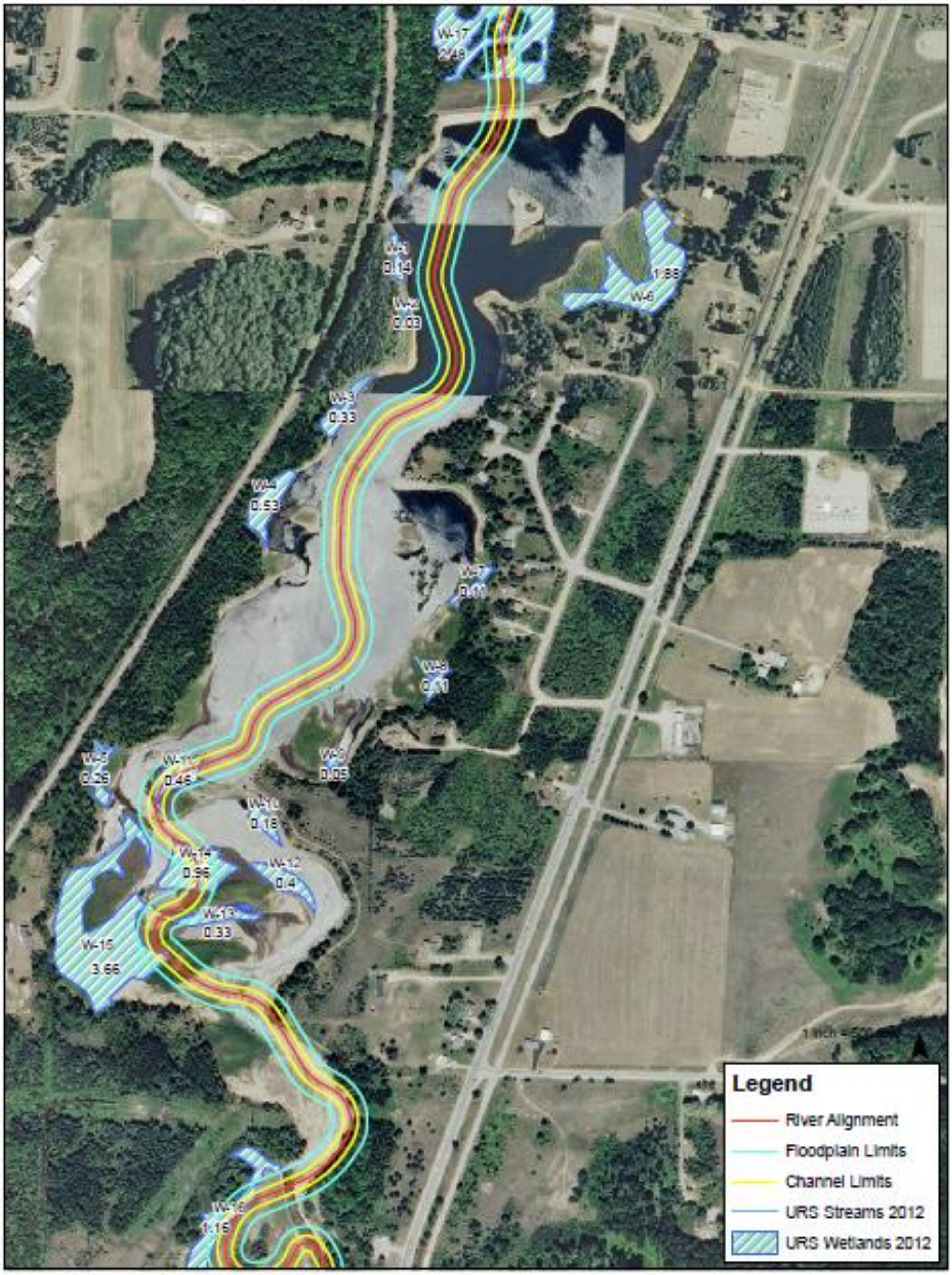

Figure 3: Boardman Pond Wetlands

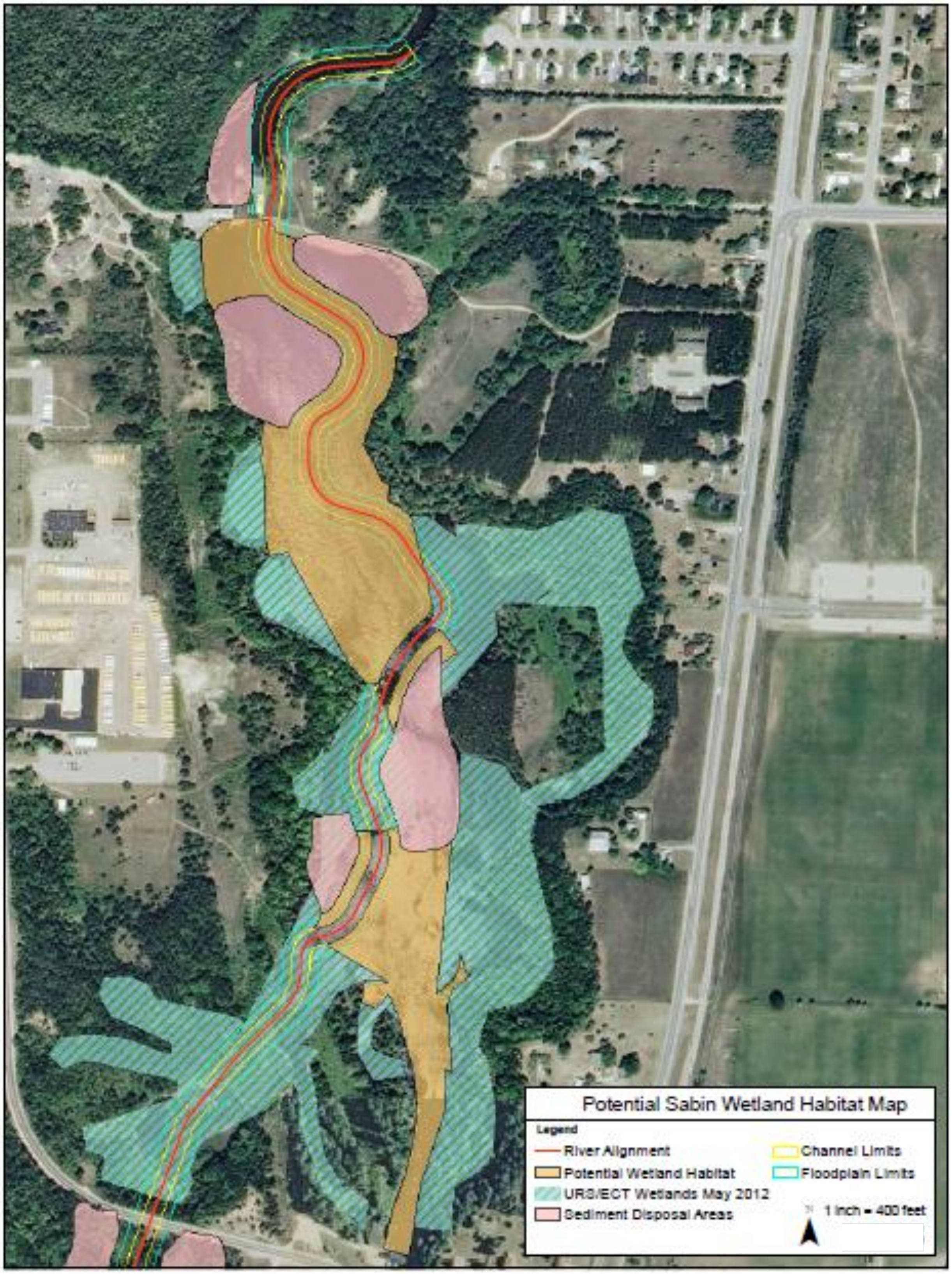

Figure 4: Potential Sabin Pond Wetlands

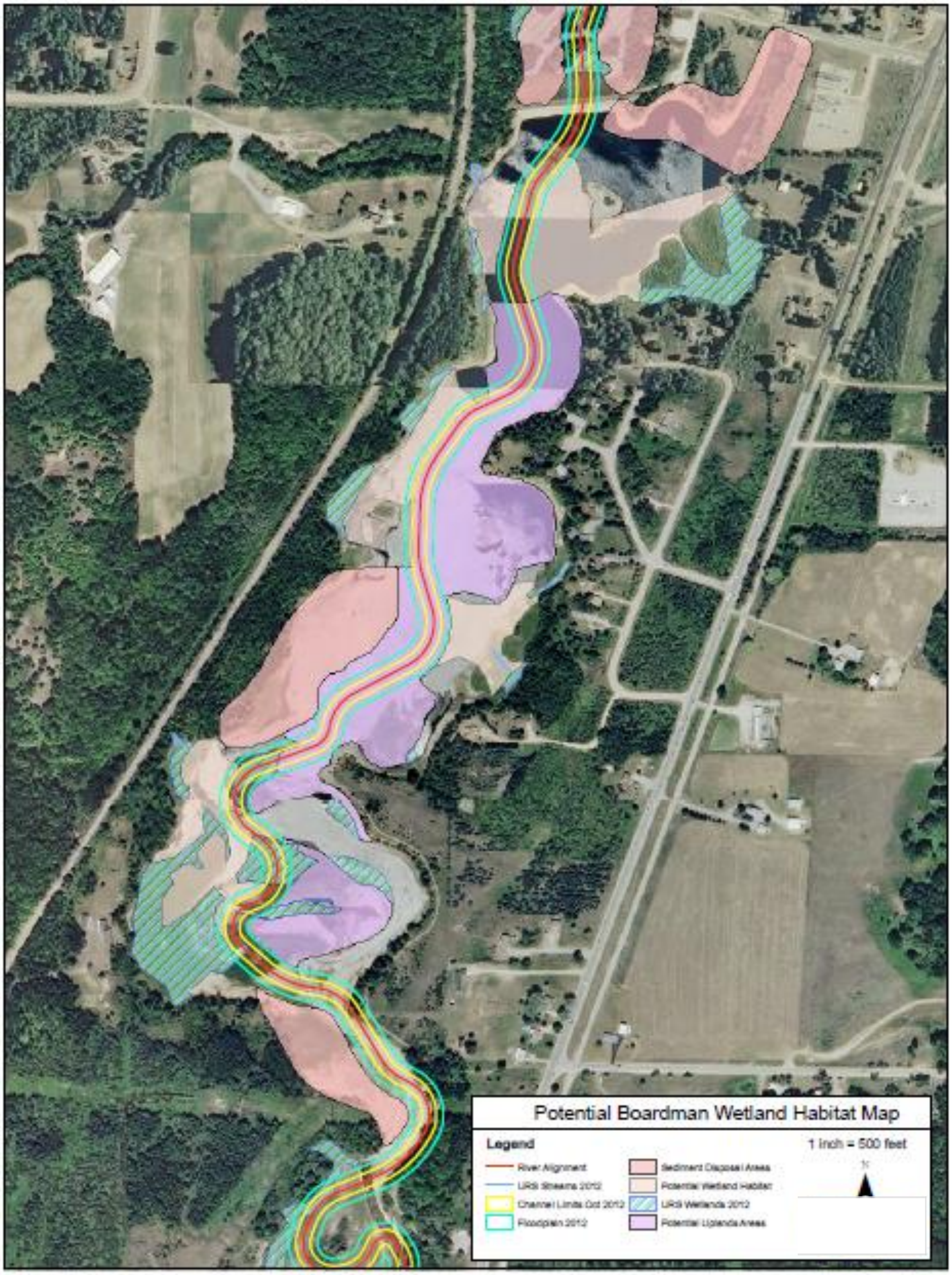

Figure 5: Potential Boardman Pond Wetlands

Table 10: Wetland Quantity Impacts for Sabin Pond (Segment 4)		
Category	**No Action and Dam Modification Alternatives (acres)**	**Dam Removal Alternatives (acres)**
Impoundment-Open Water	25.0	0.0
Impoundment-Aquatic Vegetation	15.0	0.0
River Channel-Open Water	1.6	6.4
Total Surface Water	41.6	6.4
PEM/PSS	0.1	0.1
PFO	9.4	9.4
PFO/PSS	0.3	0.3
PFO/PSS/PEM/OW	6.9	6.9
Total Wetlands Outside Impoundment	16.7	16.7
PEM/PSS Forming Within Impoundment	0.0	30.5
Total Upland	1.4	6.1
Total Area	59.7	59.7
Wetland Gain/Loss	**0.0**	**+30.5**

PEM = palustrine emergent
PSS = palustrine scrub-shrub
PFO = palustrine forested
OW = open water

Table 11: Wetland Quantity Impacts for Boardman Pond (Segment 5)		
Category	**No Action and Dam Modification Alternatives (acres)**	**Dam Removal Alternatives (acres)**
Impoundment-Open Water	78.0	0.0
River Channel-Open Water	0.0	11.0
Total Surface Water	78.0	11.0
PEM/PSS/PFO*	2.5	1.4
Total Wetlands Outside Impoundment	2.5	1.1
PEM	10.6	0.0
PEM/PSS	0.0	38.5
Total Wetlands Forming Within Impoundment	10.6	38.5
Total Upland	0.0	40.5
Total Area	91.1	91.1
Wetland Gain/Loss	**0.0**	**+26.5**

* Wetland boundaries and size estimate due to access issues, estimations based of field observations and map review.
PEM = palustrine emergent
PSS = palustrine scrub-shrub
PFO = palustrine forested

Table 12: Wetland Quality Impacts for Sabin Pond (Segment 4)						
Wetland ID	No Action and Dam Modification Alternatives (acres)			Dam Removal Alternatives (acres)		
	Wetland Type	MiRAM Score	Wetland Size (acres)	Wetland Type	MiRAM Score	Wetland Size (acres)
Wetland A	PFO	69.0	9.40	PFO	69.0	9.40
Wetland B	PFO/PEM/PSS/OW	69.0	6.89	PFO/PEM/PSS/OW	69.0	6.89
Wetland C	PSS/PFO	67.5	0.21	PSS/PFO	67.5	0.21
Wetland D	PSS/PFO	65.5	0.09	PEM/PSS/PFO	67.5	1.06
Wetland E	PEM/PSS	53.5	0.14	PEM/PSS	55.5	0.93
Wetland 1	-	-	0.00	PEM/PSS	53.5	11.73
Wetland 5	-	-	0.00	PEM/PSS	49.5	4.66
Wetlands 6, 7, 8, and 9	-	-	0.00	PEM/PSS	55.0	12.30

MiRAM = Michigan Rapid Assessment Method
PEM = palustrine emergent
PSS = palustrine scrub-shrub
PFO = palustrine forested
OW = open water

Table 13: Wetland Quality Impacts for Boardman Pond (Segment 5)						
Wetland ID	No Action and Dam Modification Alternatives (acres)			Dam Removal Alternatives (acres)		
	Wetland Type	MiRAM Score	Wetland Size (acres)	Wetland Type	MiRAM Score	Wetland Size (acres)
Wetland 1	PEM	36.0	0.14	PEM/PSS*	48.0*	15.25*
Wetland 2	PEM	34.0	0.03			
Wetland 6	PEM	39.0	1.88			
Wetland 3	PEM	40.0	0.33	PEM/PSS*	51.0*	4.33*
Wetland 4	PEM	41.0	0.53			
Wetland 7	PEM	25.0	0.11	PEM/PSS*	43.0*	3.57*
Wetland 8	PEM	26.0	0.11			
Wetland 9	PEM	24.0	0.05			
Wetland 5	PEM	37.0	0.26	PEM/PSS*	55.0*	14.24*
Wetland 10	PEM	27.0	0.18			
Wetland 11	PEM	32.0	0.46			
Wetland 12	PEM	32.0	0.40			
Wetland 13	PEM	30.0	0.33			
Wetland 14	PEM	32.0	0.96			
Wetland 15	PEM	49.0	3.66			
Wetland 16	PEM	37.0	1.16	PEM	40.0	1.16
Wetland 17	PEM/PSS/PFO	60.0	2.48	PEM/PSS/PFO	51.0	1.08

* An expansion of wetland habitat due to dam removal has caused these designated individual wetlands to merge into large wetland complexes.
PEM = palustrine emergent
PSS = palustrine scrub-shrub

Table 14: Wetland AAHU Scores for Project Alternatives			
Alternative	**Sabin Pond**	**Boardman Pond**	**Total**
2: Modify Union	1151	575	1726
6: Remove Sabin	2796	575	3371
3: Modify Union, Remove Sabin	2796	575	3371
9: Modify Sabin	1151	575	1726
10: Modify Union and Sabin	1151	575	1726
7: Remove Boardman	1151	1991	3142
4: Modify Union, Remove Boardman	1151	1991	3142
11: Modify Boardman	1151	575	1726
12: Modify Union and Boardman	1151	575	1726
8: Remove Sabin and Boardman	2796	1991	4787
5: Modify Union and Remove Sabin and Boardman	2796	1991	4787
13: Modify Sabin and Boardman	1151	575	1726
14: Modify Union, Sabin and Boardman	1151	575	1726
1: No Action	1151	575	1726

Table 15: Wetlands AAHU Scores vs. No Action Alternative	
Alternative	**Score Differential**
5: Modify Union and Remove Sabin and Boardman	3061
8: Remove Sabin and Boardman	3061
3: Modify Union, Remove Sabin	1645
6: Remove Sabin	1645
4: Modify Union, Remove Boardman	1416
7: Remove Boardman	1416
14: Modify Union, Sabin and Boardman	0
Modify Union and Sabin	0
Modify Union and Boardman	0
2: Modify Union	0
13: Modify Sabin and Boardman	0
9: Modify Sabin	0
11: Modify Boardman	0

3.3.4 Sea Lamprey Control Assessment

Project alternatives involving dam removal and fish passage modification pose the risk of increasing available habitat for the invasive sea lamprey (*Petromyzon marinus*). Historically, the Union Street Dam served as a lamprey barrier but several year classes of larval sea lamprey were discovered in the Boardman River between the Union Street Dam and the Sabin Dam in the Fall of 2010. Investigation to identify how sea lamprey traversed this historical barrier is ongoing (Adair 2010) and the river segment between the Union Street and the Sabin Dams was treated with lampricide in 2010 and 2011. The Union Street Dam was subsequently repaired to return it to a barrier impermeable to sea lamprey. While monitoring is ongoing as of April 2014 to confirm that the repairs were effective, for the purpose of this analysis, the Union Street Dam is treated as an effective sea lamprey barrier. The No Action Alternative would consider the Union Street Dam as being able to stop migrating adult sea lamprey and the infestation of the river streambed up to the Sabin Dam.

3.3.4.1 Methodology

The impacts to usable sea lamprey habitat and subsequent, necessary control measures were analyzed to quantify the benefits of sea lamprey control for each project alternative. The basic habitat unit used for this assessment was river mile protected and each project alternative was examined to determine how many additional river miles became either available or inaccessible to sea lamprey infestation. By selecting river mile as the habitat unit, cost effectiveness can easily be analyzed for either lampricide treatments and/or construction of new physical barriers for lamprey control associated with different project alternatives. Several project alternatives include the measure of modifying the Union Street Dam and construction of a sea lamprey barrier downstream of Kids Creek. This measure entails modifying the Union Street Dam for downstream passage of sturgeon to coincide with the manual transfer of sturgeon upstream and construction of a sea lamprey barrier downstream of the confluence of the Boardman River and Kids Creek. This would prohibit sea lamprey from migrating into Kids Creek and a large portion the Boardman River between the Union Street Dam and Grand Traverse Bay. Accordingly, AAHU modeling for sea lamprey control takes into account this additional project measure and expanded the potential project alternatives.

3.3.4.2 Results

AAHU scores for each alternative are found in Tables 16 and 17. Table 16 shows the river miles protected from sea lamprey infestation for each river segment along with a total AAHU score. The AAHU scores were corrected by a factor of 100 to remove decimals.

Table 16: Sea Lamprey Control AAHU Scores for Project Alternatives												
Alternative	**Segment**											**Total**
	Kids Creek	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9A**	**9B**	
Length (miles)	**4.50**	**1.14**	**2.14**	**2.15**	**1.04**	**1.34**	**12.03**	**1.63**	**6.95**	**3.00**	**3.00**	
2: Modify Union	0	0	214	215	104	134	1203	163	695	300	300	3328
15: Modify Union with Kids Creek Barrier	450	64	214	215	104	134	1203	163	695	300	300	3842
6: Remove Sabin	0	0	214	215	104	134	1203	163	695	300	300	3328
3: Modify Union, Remove Sabin	0	0	214	215	104	134	1203	163	695	300	300	3328
16: Modify Union with Kids Creek Barrier, Remove Sabin	450	64	214	215	104	134	1203	163	695	300	300	3842
9: Modify Sabin	0	0	214	215	104	134	1203	163	695	300	300	3328
10: Modify Union and Sabin	0	0	214	215	104	134	1203	163	695	300	300	3328
17: Modify Union with Kids Creek Barrier, Modify Sabin	450	64	214	215	104	134	1203	163	695	300	300	3842
7: Remove Boardman	0	0	214	215	104	134	1203	163	695	300	300	3328
4: Modify Union, Remove Boardman	0	0	214	215	104	134	1203	163	695	300	300	3328
18: Modify Union with Kids Creek Barrier, Remove Boardman	450	64	214	215	104	134	1203	163	695	300	300	3842
11: Modify Boardman	0	0	214	215	104	134	1203	163	695	300	300	3328
12: Modify Union and Boardman	0	0	214	215	104	134	1203	163	695	300	300	3328
19: Modify Union with Kids Creek Barrier, Modify Boardman	450	64	214	215	104	134	1203	163	695	300	300	3842
8: Remove Sabin and Boardman	0	0	214	215	104	134	1203	163	695	300	300	3328
5: Modify Union and Remove Sabin and Boardman	0	0	214	215	104	134	1203	163	695	300	300	3328
5A: Modify Union with Kids Creek Barrier, Remove Sabin and Boardman	450	64	214	215	104	134	1203	163	695	300	300	3842
13: Modify Sabin and Boardman	0	0	214	215	104	134	1203	163	695	300	300	3328
14: Modify Union, Sabin and Boardman	0	0	214	215	104	134	1203	163	695	300	300	3328
20: Modify Union with Kids Creek Barrier, Modify Sabin and Boardman	450	64	214	215	104	134	1203	163	695	300	300	3842
1: No Action	0	0	214	215	104	134	1203	163	695	300	300	3328

Table 17: Sea Lamprey Control AAHU Scores vs. No Action Alternative	
Alternative	**Score Differential**
5A: Modify Union with Kids Creek Barrier, Remove Sabin and Boardman	514
18: Modify Union with Kids Creek Barrier, Remove Boardman	514
16: Modify Union with Kids Creek Barrier, Remove Sabin	514
20: Modify Union with Kids Creek Barrier, Modify Sabin and Boardman	514
17: Modify Union with Kids Creek Barrier, Modify Sabin	514
19: Modify Union with Kids Creek Barrier, Modify Boardman	514
15: Modify Union with Kids Creek Barrier	514
5: Modify Union and Remove Sabin and Boardman	0
4: Modify Union, Remove Boardman	0
3: Modify Union, Remove Sabin	0
14: Modify Union, Sabin and Boardman	0
10: Modify Union and Sabin	0
12: Modify Union and Boardman	0
2: Modify Union	0
7: Remove Boardman	0
13: Modify Sabin and Boardman	0
9: Modify Sabin	0
11: Modify Boardman	0
6: Remove Sabin	0
8: Remove Sabin and Boardman	0

3.3.4.3 Conclusions

The results of AAHU analysis for sea lamprey control indicate that the construction of a barrier downstream of Kids Creek is best technique to limit this invasive species' impact on the Boardman River. Consequently, the project alternatives that include limiting sea lamprey access to the Boardman River prior to Kids Creek scored the highest as a result of having the most river miles protected from lamprey infestation. Project alternatives not involving this measure scored similar to the No Action Alternative.

3.4 SUMMARY

When the AAHU scores from fisheries, wetlands, and sea lamprey control assessments are compiled, project alternatives can be ranked based on overall benefit to the habitat of the Boardman River system. Tables 18 and 19 summarize the results of AAHU modeling.

The highest scoring project alternative is modifying the Union Street Dam with construction of a sea lamprey barrier at Kids Creek and removing both the Sabin and Boardman Dams. This alternative would protect the most river miles from sea lamprey infestation, conserve and create the most wetland habitat, and restore the most usable aquatic habitat for native coldwater fish species. Generally, the project alternatives that involve dam removal scored high because of the creation of wetland habitat and the restoration of aquatic habitat suitable for native coldwater fish species.

Table 18: Total AAHU Score for Project Alternatives				
Alternative	**Fisheries AAHU Score**	**Wetlands AAHU Score**	**Sea Lamprey Control AAHU Score**	**Total AAHU Score**
5A: Modify Union with Kids Creek Barrier, Remove Sabin and Boardman	3928	4787	3842	12557
5: Modify Union and Remove Sabin and Boardman	3928	4787	3328	12043
8: Remove Sabin and Boardman	3349	4787	3328	11464
16: Modify Union with Kids Creek Barrier, Remove Sabin	3176	3371	3842	10389
18: Modify Union with Kids Creek Barrier, Remove Boardman	3233	3142	3842	10217
3: Modify Union, Remove Sabin	3176	3371	3328	9875
6: Remove Sabin	3089	3371	3328	9788
4: Modify Union, Remove Boardman	3233	3142	3328	9703
7: Remove Boardman	3168	3142	3328	9638
20: Modify Union with Kids Creek Barrier, Modify Sabin and Boardman	3108	1726	3842	8676
17: Modify Union with Kids Creek Barrier, Modify Sabin	2984	1726	3842	8552
15: Modify Union with Kids Creek Barrier	2973	1726	3842	8541
19: Modify Union with Kids Creek Barrier, Modify Boardman	2973	1726	3842	8541
14: Modify Union, Sabin and Boardman	3108	1726	3328	8162
10: Modify Union and Sabin	2984	1726	3328	8038
2: Modify Union	2973	1726	3328	8027
12: Modify Union and Boardman	2973	1726	3328	8027
9: Modify Sabin	2908	1726	3328	7962
11: Modify Boardman	2908	1726	3328	7962
13: Modify Sabin and Boardman	2908	1726	3328	7962
1: No Action	2908	1726	3328	7962

Table 19: Total AAHU Score vs. No Action Alternative	
Alternative	**Score Differential**
5A: Modify Union with Kids Creek Barrier, Remove Sabin and Boardman	4595
5: Modify Union and Remove Sabin and Boardman	4081
8: Remove Sabin and Boardman	3502
16: Modify Union with Kids Creek Barrier, Remove Sabin	2427
18: Modify Union with Kids Creek Barrier, Remove Boardman	2255
3: Modify Union, Remove Sabin	1913
6: Remove Sabin	1826
4: Modify Union, Remove Boardman	1741
7: Remove Boardman	1676
20: Modify Union with Kids Creek Barrier, Modify Sabin and Boardman	714
17: Modify Union with Kids Creek Barrier, Modify Sabin	590
15: Modify Union with Kids Creek Barrier	579
19: Modify Union with Kids Creek Barrier, Modify Boardman	579
14: Modify Union, Sabin and Boardman	200
10: Modify Union and Sabin	76
2: Modify Union	65
12: Modify Union and Boardman	65
9: Modify Sabin	0
11: Modify Boardman	0
13: Modify Sabin and Boardman	0

4 References

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